Electroweak Model and Constraints on New Physics

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PDG Collaboration/Advisory Meeting

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- **Recommendation of advisory committee in 2010 report**
- **What's new**
- **Future prospects**

Overseer: Michael Barnett

Recommendation of advisory committee

- Recommend a more didactic approach to the Electroweak review following the example of the new QCD review.

- Make it more useful to the intended audience.

- Put the theoretical framework all at the beginning, and follow up with the fits and the searches for new physics at the end.

- Add some details about the NuTeV result and the current status.

----> All the suggestions are implemented in 2012 edition !

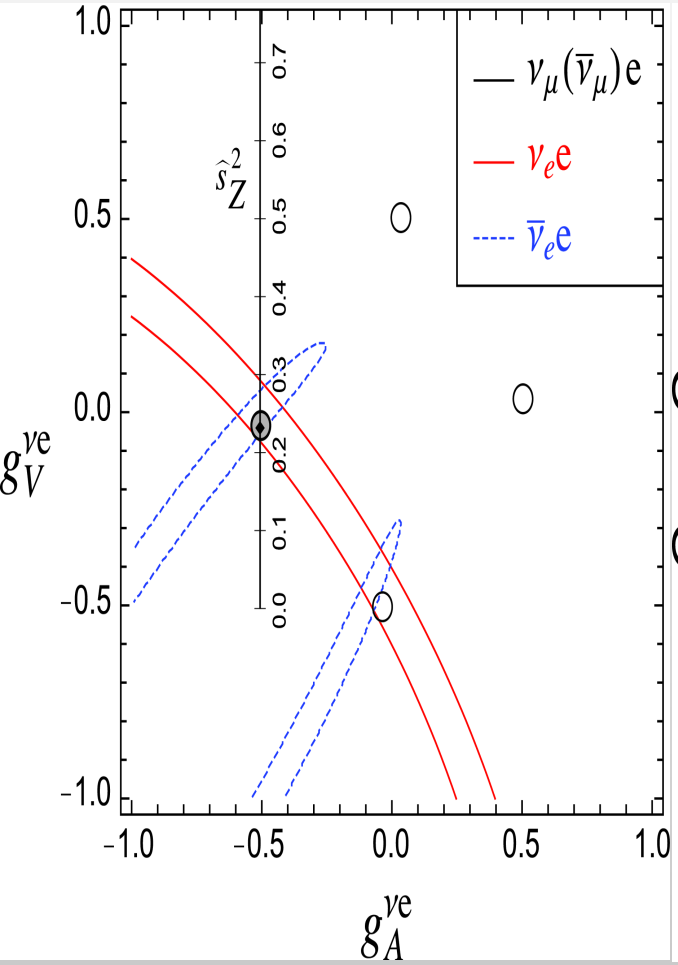
What's new

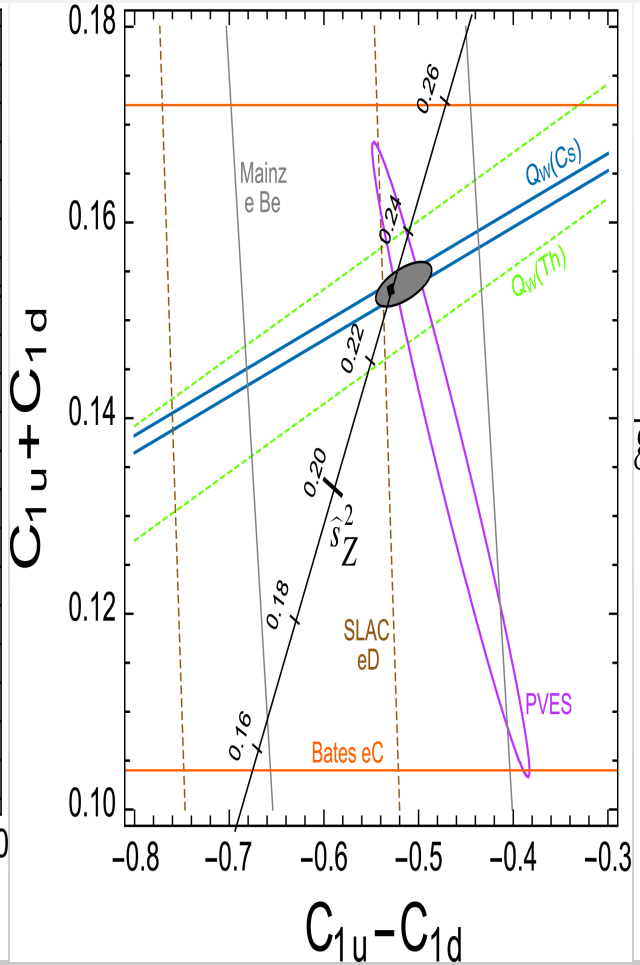
- Included Higgs potential and tree-level mass formulas for electroweak bosons in Section 1 (Introduction)
  - $V(\Phi) = \mu^2\Phi^+\Phi + \lambda^2/2(\Phi^+\Phi)^2$
  - $M_H=\lambda\nu$, $M_W=1/2g\nu$, $M_Z=1/2\mathrm{sqrt}(g^2+g'^2)\nu$, $M_\gamma=0$
- As recommended by the previous Advisory Committee, we moved most of the discussion of radiative corrections to Section 2 (Renormalization and radiative corrections)

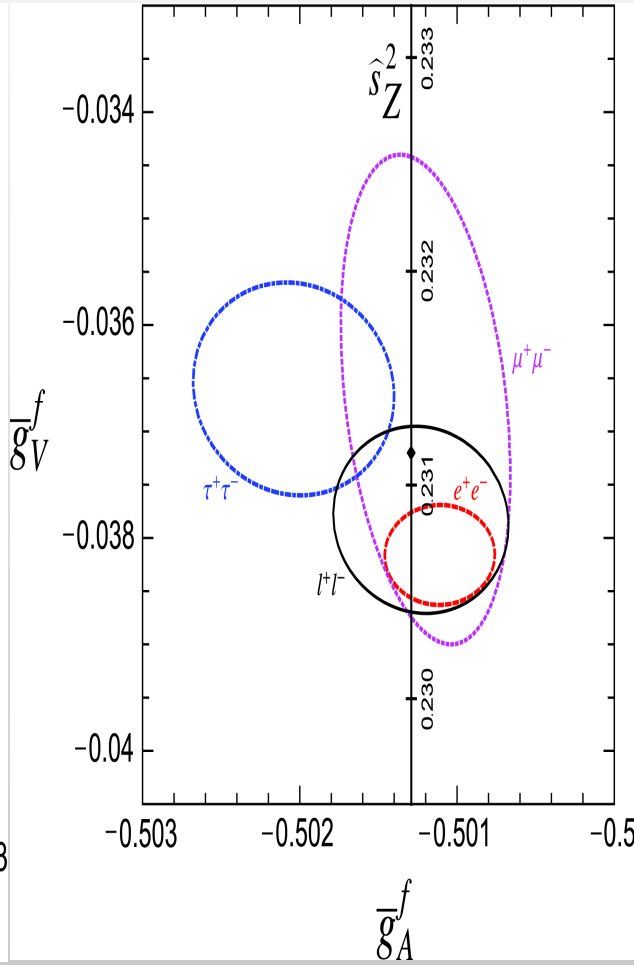
- Extracted new precise value of the Fermi constant and slightly redefined it
  - $GF=1.1663787(6)10^{-5}$ GeV^{-2}, derived from τ_μ with additional correction of 3/5 M_μ^2/M_W^2

What's new

- Included new figures (1, 2 and 4) on effective couplings







What's new

- Consulted with the spokespeople of the NuTeV Collaboration and updated discussion of NuTeV result on R_ν and $R_{\bar{\nu}}$. For the time being, we removed these from the electroweak fits (the collaboration is working on an update which will take important developments into account)

- Consulted with the group of M. Davier on the hadronic vacuum polarization contributions to the running alphaQED and the muon anomalous magnetic moment. In the spirit of a global analysis we used all data, i.e. we included the τ-decay spectral functions and accounted for correlations.

What's new

- Consulted with S. Bethke, G. Dissertori and G. P. Salam on the extraction of αs from τ and Zdecays.

- In addition to the usual electroweak fits with a floating Higgs mass, we also performed fits with MH fixed to 124.5 GeV, which was the value most consistent with the LHC Higgs candidates as of december 2011. Otherwise, the review would already be somewhat out-of-date by now.

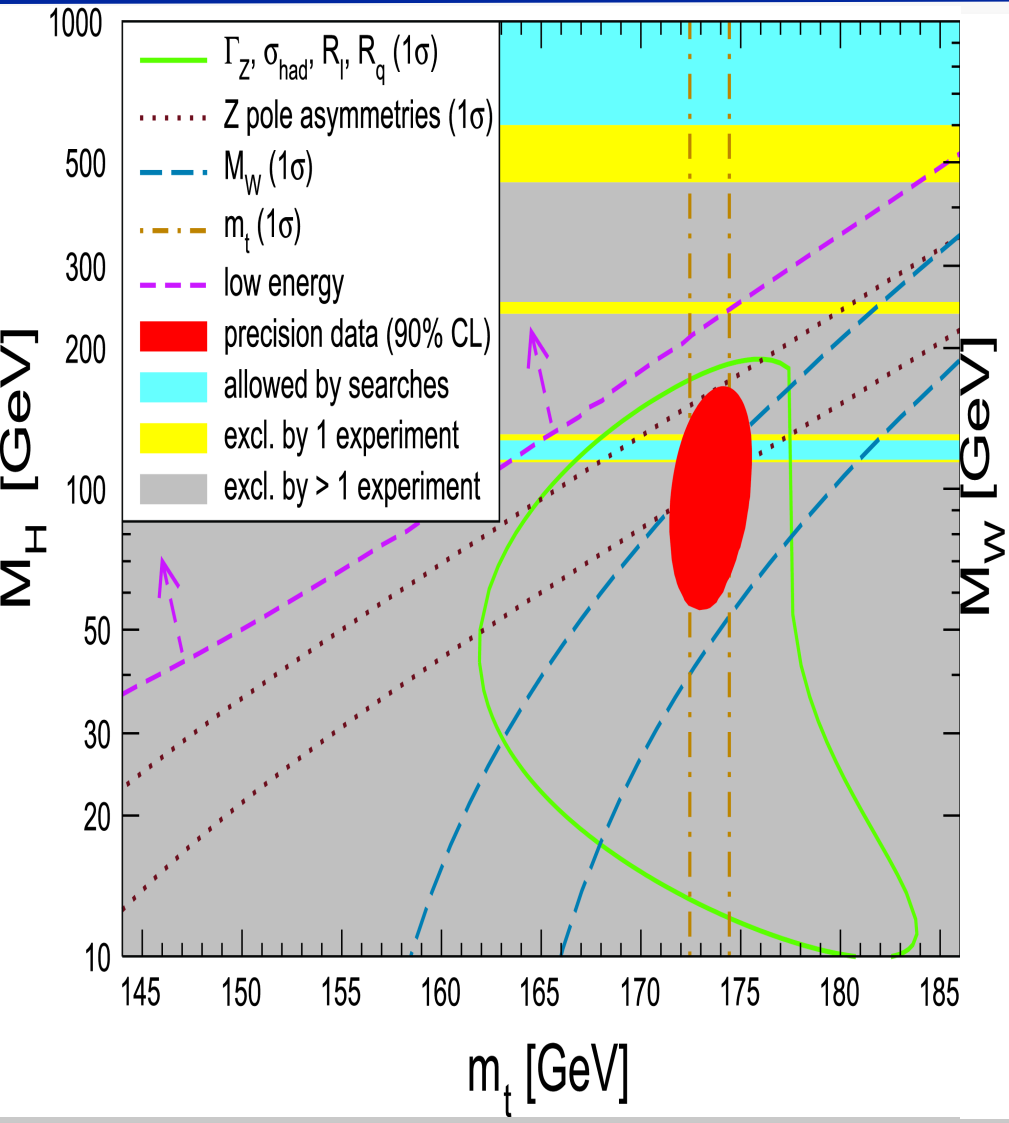
Input Data

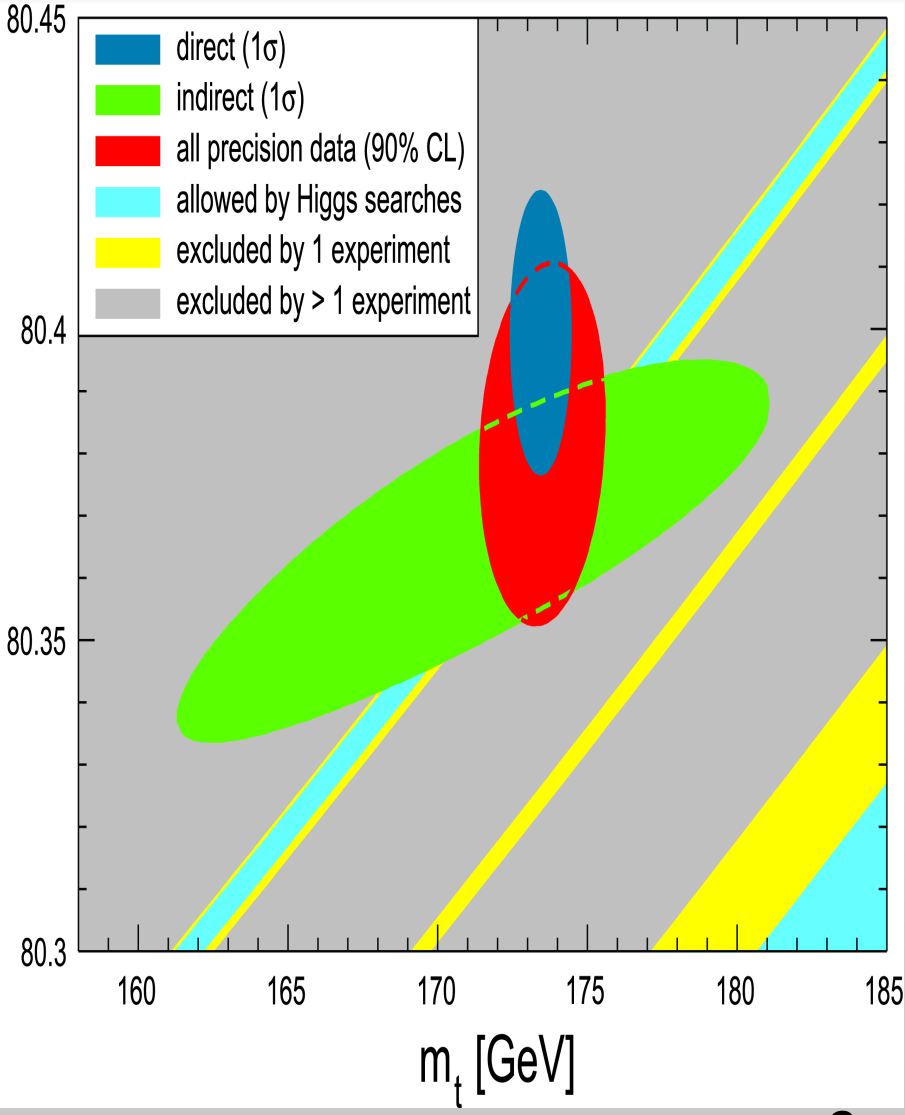
Quantity	Value	Standard Model	Pull	Dev.
m_t [GeV]	173.4 ± 1.0	173.5 ± 1.0	−0.1	−0.3
M_W [GeV]	80.420 ± 0.031	80.381 ± 0.014	1.2	1.6
	80.376 ± 0.033		−0.2	0.2
$g_V^{\nu e}$	-0.040 ± 0.015	-0.0398 ± 0.0003	0.0	0.0
$g_A^{\nu e}$	-0.507 ± 0.014	-0.5064 ± 0.0001	0.0	0.0
$Q_W(e)$	-0.0403 ± 0.0053	-0.0474 ± 0.0005	1.3	1.3
$Q_W(\mathrm{Cs})$	-73.20 ± 0.35	-73.23 ± 0.02	0.1	0.1
$Q_W(\mathrm{Tl})$	-116.4 ± 3.6	-116.88 ± 0.03	0.1	0.1
τ_τ [fs]	291.13 ± 0.43	290.75 ± 2.51	0.1	0.1
$\frac{1}{2}(g_\mu - 2 - \frac{\alpha}{\pi})$	$(4511.07 \pm 0.77) \times 10^{-9}$	$(4508.70 \pm 0.09) \times 10^{-9}$	3.0	3.0

Input Data

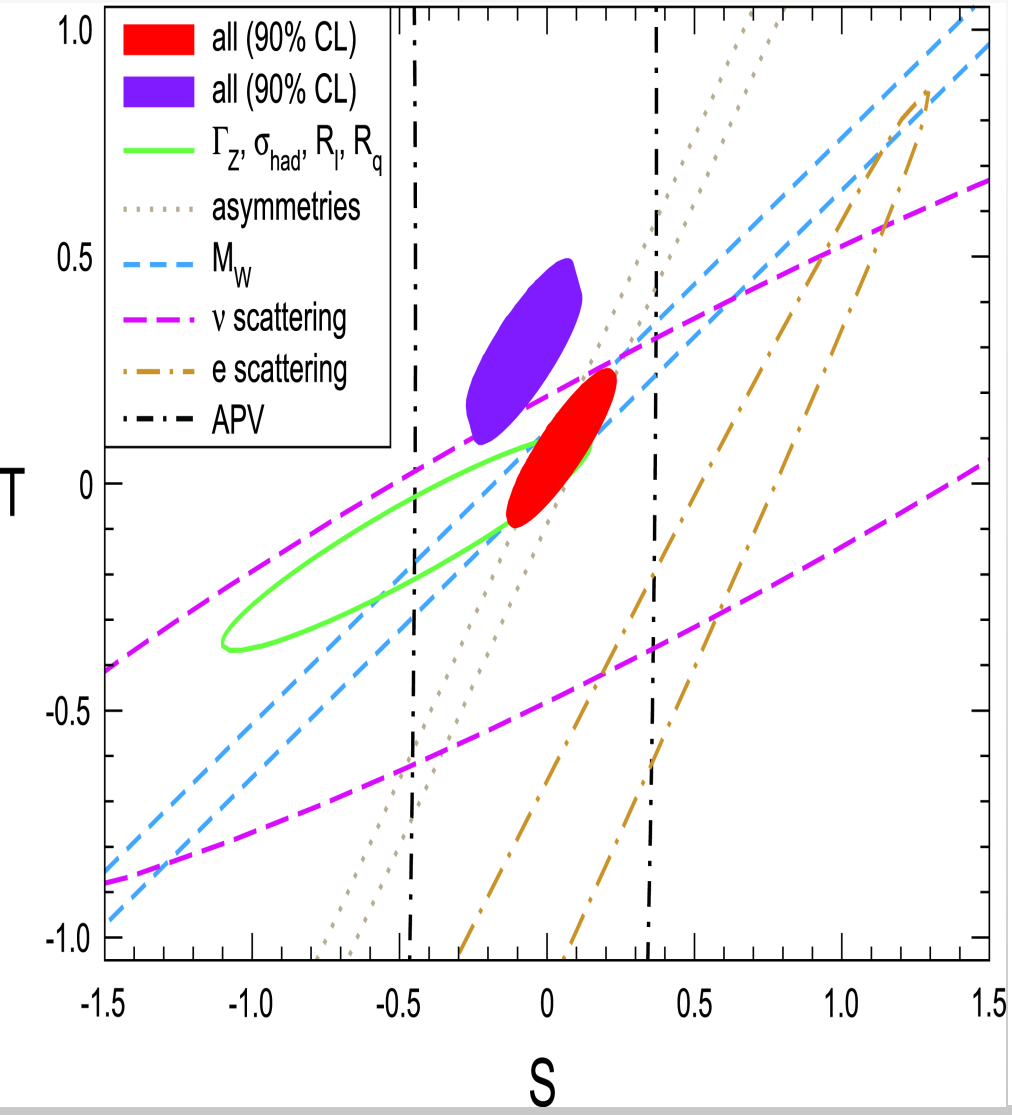
Quantity	Value	Standard Model	Pull	Dev.
M_Z [GeV]	91.1876 ± 0.0021	91.1874 ± 0.0021	0.1	0.0
Γ_Z [GeV]	2.4952 ± 0.0023	2.4961 ± 0.0010	−0.4	−0.2
Γ(had) [GeV]	1.7444 ± 0.0020	1.7426 ± 0.0010	—	—
Γ(inv) [MeV]	499.0 ± 1.5	501.69 ± 0.06	—	—
$\Gamma(\ell^+\ell^-)$ [MeV]	83.984 ± 0.086	84.005 ± 0.015	—	—
σ_{had}[nb]	41.541 ± 0.037	41.477 ± 0.009	1.7	1.7
R_e	20.804 ± 0.050	20.744 ± 0.011	1.2	1.3
R_μ	20.785 ± 0.033	20.744 ± 0.011	1.2	1.3
R_τ	20.764 ± 0.045	20.789 ± 0.011	−0.6	−0.5
R_b	0.21629 ± 0.00066	0.21576 ± 0.00004	0.8	0.8
R_c	0.1721 ± 0.0030	0.17227 ± 0.00004	−0.1	−0.1
$A_{FB}^{(0,e)}$	0.0145 ± 0.0025	0.01633 ± 0.00021	−0.7	−0.7
$A_{FB}^{(0,\mu)}$	0.0169 ± 0.0013		0.4	0.6
$A_{FB}^{(0,\tau)}$	0.0188 ± 0.0017		1.5	1.6
$A_{FB}^{(0,b)}$	0.0992 ± 0.0016	0.1034 ± 0.0007	−2.6	−2.3
$A_{FB}^{(0,c)}$	0.0707 ± 0.0035	0.0739 ± 0.0005	−0.9	−0.8
$A_{FB}^{(0,s)}$	0.0976 ± 0.0114	0.1035 ± 0.0007	−0.5	−0.5
$s_\ell^2(A_{FB}^{(0,q)})$	0.2324 ± 0.0012	0.23146 ± 0.00012	0.8	0.7
	0.23200 ± 0.00076		0.7	0.6
	0.2287 ± 0.0032		−0.9	−0.9
A_e	0.15138 ± 0.00216	0.1475 ± 0.0010	1.8	2.1
	0.1544 ± 0.0060		1.1	1.3
	0.1498 ± 0.0049		0.5	0.6
A_μ	0.142 ± 0.015		−0.4	−0.3
A_τ	0.136 ± 0.015		−0.8	−0.7
	0.1439 ± 0.0043		−0.8	−0.7
A_b	0.923 ± 0.020	0.9348 ± 0.0001	−0.6	−0.6
A_c	0.670 ± 0.027	0.6680 ± 0.0004	0.1	0.1
A_s	0.895 ± 0.091	0.9357 ± 0.0001	−0.4	− 0.4

SM Fit Results





Constrains on New Physics



Z'	EW	ATLAS	CMS	CDF	DØ	LEP 2	M_H
Z_χ	1,141	1,640	–	930	903	673	171^{+493}_{-89}
Z_ψ	147	1,490	1,620	917	891	481	97^{+31}_{-25}
Z_η	427	1,540	–	938	923	434	423^{+577}_{-350}
Z_{LR}	998	–	–	–	–	804	804^{+174}_{-35}
Z_S	1,257	1,600	–	858	822	–	149^{+353}_{-68}
Z_{SM}	1,403	1,830	1,940	1,071	1,023	1,787	331^{+669}_{-246}
Z_{string}	1,362	–	–	–	–	–	134^{+209}_{-58}

Future Prospects

- With the Higgs boson established at the time of the next update, we will no longer work with reference values for M_H and M_t, but rather with values best describing the data throughout.

- Table 8: using a modern set of parton distributions, we will update the model independent 4-Fermi operator coefficients.

- Any suggestions are welcome